

*C. The Observations of the internal Contact of Venus with the Sun's Limb, in the late Transit, made in different Places of Europe, compared with the Time of the same Contact observed at the Cape of Good Hope, and the Parallax of the Sun from thence determined. By James Short, A. M. F. R. S.*

Read Dec. 9, 1762. IN the summer of the year 1760, the Royal Society resolved to send some proper persons to proper places of the globe, in order to observe the transit of Venus, which was to happen on the 6th of June, 1761. In consequence of this resolution, they appointed messieurs Maskelyne and Waddington to go to the island of St. Helena, and messieurs Mason and Dixon to go to Bencoolen, a settlement belonging to the East India Company, on the island of Sumatra. Two reflecting telescopes of 2 feet focal length each, with an object glass micrometer of 40 feet focus adapted to one of them, an astronomical clock, and an equal-altitude instrument were ordered, by the society, for each of those places. The munificence of his late and present Majesty, patrons of the Royal Society, defrayed the expence.

Mr. Maskelyne and his assistant arrived at St. Helena in the month of April 1761; but Mr. Mason and his assistant, being detained at Plymouth by an accident, on their arrival at the Cape of Good Hope in the month of April 1761, found it was too late to

to reach Bencoolen, and therefore resolved to stay at the Cape, and to make their observations there; and it was extremely fortunate they did so, for, by reason of cloudy weather, Mr. Maskelyne was hindered from making the proper observations, and in that case, the observation of the internal contact at the egress at Bencoolen, when compared with the same observation at Greenwich, could have determined nothing with regard to the parallax of the Sun.

To determine the parallax of the Sun, by means of the observations of the internal contact of Venus with the Sun's limb, made at two different places, it is absolutely necessary that the difference of longitude between these two places be exactly determined. For this purpose Mr. Mason applied himself assiduously to observe the eclipses of Jupiter's satellites, and Mr. Green, the assistant observer at Greenwich, observed as many of the same eclipses, as the unfavourable season would allow. Dr. Bevis and myself likewise observed the same eclipses in Surry-Street, London. The insufficiency of these sort of observations in determining the longitude of places, where accuracy is required, is well known to those who have the practice of them.

By comparing the observations of the first and second satellites made at the Cape with those made in Surry-Street \*, the difference of longitude between Greenwich and the Cape, comes out, on a mean,  $= 1^h 13' 30''$ , and rejecting those of the second satellite, which are always more uncertain than those of the first, I fix the difference of longitude between Greenwich and the Cape of Good Hope  $= 1^h 13' 35''$ , which I have made use of in the following computations.

\* Vid. Phil. Trans. vol. LII. part I.

In order to ascertain the Sun's parallax, with more certainty, I have compared the observation of the internal contact at the egress at the Cape, with the observations of the same contact made at fifteen different places in Europe. But, before I proceed any farther, I shall mention the times of such observations, from whence I had them; and the longitudes of those places, and from whence I likewise had those.

Internal Contact at  $9^h\ 46' 59''$ 

		b. t. "
Greenwich	- at -	8 19 0 from Phil. Trans. Longitude from the Cape
Shirburn Cast.	at 8 15 10 from ditto	= 1 13 35 W. from Phil. Transact.
		- - - - from Greenwich = 0 4 1 W. from ditto.
		8 15 14
Savile-House	- at 8 18 22 from ditto	- - - - from Greenwich = 0 0 30 W. from ditto.
Leskeard	- at 8 0 21 from ditto	- - - - from Greenwich = 0 18 32 W. from ditto.
Paris	- - at 8 28 25 from ditto	- - - - from Greenwich = 0 9 10 E. from Conn. des Tems.
		8 28 29
Bologna	- - at 9 4 54 from ditto	- - - - from Paris - - = 0 36 5 E. from ditto.
		9 5 0
Rome	- - - at 9 9 36 from a private letter	- - from Paris - - = 0 40 37 E. from ditto.
Drontheim	- at 9 1 49 from a private letter	- - from Greenwich = 0 43 58 E. from a private letter.
Upfal	- - - at 9 28 3 from Phil. Trans.	- - from Paris - - = 1 1 10 E. from Phil. Trans.
		9 28 9
Stockholm	- - at 9 30 8 from ditto	- - - - from Paris - - = 1 3 10 E. from Conn. des Tems.
		9 30 11
Hernofand	- at 9 28 52 from Swedish acts	- - - from Paris - - = 1 2 12 E. from Phil. Trans.
Calmar	- at 9 23 40 from ditto	- - - from Stockholm = 0 6 27 W. from Swedish acts.
Abo	- - at 9 45 59 from Phil. Trans.	- - - from Paris - - = 1 19 17 E. from Phil. Trans.
Tornæa	- at 9 54 8 from ditto	- - - from Paris - - = 1 27 28 E. from ditto.
Cajaneburg	- at 10 8 59 from Swedish acts	- - - from Stockholm = 0 39 20 E. from Swedish acts.
Cape of G. Hope	at 9 39 48 from Phil. Trans.	- - - from Greenwich = 1 13 35 E. from Phil. Trans.
		9 39 52

As there were several observers at some places, I have therefore set down the two extreme observations, that I may afterwards take the mean of them.

One reason, I apprehend, why the observers, even at the same place, differ some seconds in the time of the contact, may arise from this, that some of them

\* In the Phil. Transactions it is at  $9^h\ 46' 59''$ , but that this is a mistake, in writing down the minutes, may be easily proved.

judged.

judged of the contact when there was no light between the limb of Venus and that of the Sun, others did not imagine the contact to happen, till they lost a part of the circumference of Venus: I shall therefore set down the difference between the observers, at the same place, that an estimate may be formed of the limit of this error.

Observers at Greenwich	-	3	Difference in observation	=	0.
at Bologna	-	4	-	-	= 6.
* at Paris	-	6	-	-	= 16.
at Sherburn Castle	2	-	-	-	= 4.
at Cambridge	2	-	-	-	= 7.
at Stockholm	2	-	-	-	= 3.
at Upsal	3	-	-	-	= 6.
at Tornea	2	-	-	-	= 14.
at Cape of G. Hope	2	-	-	-	= 4.
at Carlserona	2	-	-	-	= 6.

The mean, therefore, of all these comes out to be  $= 6''$ , 6, an error that may be committed in judging of the contact, even at the same place.

After having computed the parallaxes of longitude and latitude, on the supposition that the Sun's parallax was  $= 8'' \frac{1}{2}$ , for each of the above places, I compared the observation at each place with the observation at the Cape of Good Hope, and deduced the Sun's parallax from each, as may be seen more fully in the following table.

\* M. de la Lande, in a letter to Mr. Maskelyne, says that M. de la Caille observed with a Telescope of Mr. Dolland's construction, which was not well fitted up; it may, therefore, be presumed that there is some mistake in the observation of M. Maraldi, because his observation is later than that of M. de la Caille, and differs so considerably from the rest.

I.	2.	3.
h ' " 9 39 50 Cape 6 8 Cape. 1 13 35 = D. M. 1 11 Greenwich. 8 26 15 7 19 8 19 0 Greenwich — 4	h ' " 9 39 50 Cape 6 8 Cape. 1 17 36 = D. M. 1 12 Shirburn. 8 22 14 7 20 8 15 12 Shirburn — 13	h ' " 9 39 50 Cape. 6 8 Cape. 1 14 5 = D. M. 1 11 Savile-house. 8 25 45 7 19 8 18 22 Savile-house + 4
7 15 Sun's parallax = 8, 42	7 2 Sun's parallax 8, 15	7 23 Sun's parallax = 8, 57
4.	5.	6.
h ' " 9 39 50 Cape 6 8 Cape. 1 32 7 = D. M. 1 4 Lefkward. 8 7 43 7 12 8 0 21 Lefkward + 10	h ' " 9 39 50 Cape 6 8 Cape. 1 4 25 = D. M. 54 Paris. 8 35 25 7 2 8 28 27 Paris — 4	h ' " 9 39 50 Cape. 6 8 Cape. 0 28 20 = D. M. 29 Bologna. 6 4 57 Bologna 6 37 — 4
7 22 Sun's parallax = 8, 69	6 58 Sun's parallax = 8, 42	6 33 Sun's parallax = 8, 41
7.	8.	9.
h ' " 9 39 50 Cape 6 8 Cape. 0 23 48 = D. M. 1 3 Rome. 9 16 2 6 21 9 9 36 Rome + 5	h ' " 9 39 50 Cape 6 8 Cape. 0 29 32 = D. M. 2 38 Drontheim. 9 10 18 8 46 9 1 49 Drontheim — 17	h ' " 9 39 50 Cape. 6 8 Cape. 0 3 15 = D. M. 2 21 Upfal. 9 36 35 8 29 9 28 6 Upfal — 6
6 26 Sun's parallax = 8, 61	8 29 Sun's parallax = 8, 23	8 29 Sun's parallax = 8, 50
10.	11.	12.
h ' " 9 39 50 Cape 6 8 Cape. 0 1 15 = D. M. 2 18 Stockholm. 9 38 35 8 26 9 30 10 Stockholm — 1	h ' " 9 39 50 Cape 6 8 Cape. 0 2 13 = D. M. 2 26 Herno-fand. 9 37 37 8 34 9 28 52 Herno-fand + 11	h ' " 9 39 50 Cape. 6 8 Cape. 0 7 42 = D. M. 1 59 Calmar. 9 32 8 8 7 9 23 40 Calmar + 21
8 25 Sun's parallax = 8, 48	8 45 Sun's parallax = 8, 68	8 28 Sun's parallax = 8, 86
13.	14.	15.
h ' " 9 39 50 Cape 6 8 Cape. 0 14 52 = D. M. 2 30 Abo. 9 54 42 8 38 9 45 59 Abo — 5	h ' " 9 39 50 Cape 6 8 Cape. 0 23 3 = D. M. 3 5 Tornea. 10 2 53 9 13 9 54 8 Tornea + 28	h ' " 9 39 50 Cape. 6 8 Cape. 0 38 5 = D. M. 2 59 Cajaneburg. 10 17 55 9 7 10 8 59 Cajaneburg + 11
8 43 Sun's parallax = 8, 58	8 45 Sun's parallax = 8, 07	8 56 Sun's parallax = 8, 33

I shall explain this table by the example of the observation at Greenwich compared with the observation at the Cape, which is the first in the table.

$9^h 39' 50''$  is the mean of the times of the internal contact observed at the Cape,  $1^h 13' 35''$  is the difference of longitude between Greenwich and the Cape, this being subtracted from the time of the observed contact at the Cape, leaves  $8^h 26' 15''$  for the time the observers at Greenwich should have seen the contact, if there had been no parallax of Venus; subtracting therefore the time of the observed contact at Greenwich from this time, the remainder,  $7' 15''$  is the effect of the parallaxes of longitude and latitude at the two places of observation. But the effect of these two parallaxes at the Cape, on the supposition of the Sun's parallax being  $= 8'' \frac{1}{2}$ , is  $= 6' 8''$ , by which quantity of time the observers at the Cape should have seen the internal contact later than at the center of the earth: and the effect of the same parallaxes at Greenwich is  $= 1' 11''$ , by which quantity of time the observers at Greenwich should have seen the internal contact sooner than at the center of the earth. The sum therefore of these two quantities is  $= 7' 19''$ , by which quantity of time the observers at Greenwich should have seen the internal contact sooner than the observers at the Cape in absolute time, had the Sun's parallax been  $= 8'' \frac{1}{2}$ . But the difference in absolute time as found by observation, as above, is only  $= 7' 15''$ , therefore the Sun's parallax, by supposition, viz.  $8''$ , 5, is to the parallax of the Sun found by observation, as  $7' 19''$  is to  $7' 15''$ , which gives  $8'', 42$  for the Sun's parallax, on the day of the transit, by this observation, which

which numbers and result are set down in number 1st. and so of all the rest in the table.

By taking a mean of the results of these fifteen observations, the parallax of the Sun, on the day of the transit, comes out =  $8'', 47$ , and by rejecting the 2d, the 8th, the 12th, and 14th results, which differ the most from the rest, the Sun's parallax, on the day of the transit, by the mean of the eleven remaining ones is =  $8'', 52$ .

We have received from Sweden several observations of the total duration of the transit from the internal contact at the ingress to the internal contact at the egress, and also the observation of the same duration by M. Chappe at Tobolsk in Siberia, and by several persons in the East Indies: but the differences between these durations are too small to determine with any accuracy, the Sun's parallax from them, by comparing the duration at one place with the duration at another place. The greatest difference between them, and the duration at Tobolisk (which is the least) amounting only to  $2' 50''$ , and the least difference amounting only to  $1' 4''$ : in which small quantities the unavoidable errors of observation must bear a considerable proportion, and yet by comparing fifteen total durations observed at different places with the total duration observed at Tobolsk, I find the following results of the Sun's parallax from each of them.

Cajaneburg	=	9 50	}
Calmar	- - =	9 00	
Calcutta	- - =	9 50	
Hernosand	=	9 50	
Abo	- - - =	8 75	
Stockholm	- =	11 00	
Stockholm	- =	10 75	
Upsal	- - - =	7 25	
Upsal	- - - =	6 70	
Upsal	- - - =	9 00	
Tornea	- - =	12 00	
Tornea	- - =	14 00	
Madras	- =	9 70	
G. Mount	- =	8 50	
Tranquebar	=	8 75	

The mean of these fifteen results gives the Sun's parallax =  $9'', 56$ ; and if we reject four of them, which differ the most from the rest, the mean, of the remaining eleven, gives the sun's parallax =  $8'', 69$ .

However, on calculation by another method, I find so great an agreement between them, on the supposition that the Sun's parallax is =  $8'' \frac{1}{2}$ , that I have determined the Sun's parallax from them also, as a corroboration of the Sun's parallax being very nearly the same as found by the observations of the internal contact; and this is done in such a manner that each observation of the total duration, at any one place, determines the Sun's parallax independent of any observation of the same duration made at any other place, and in which an exact knowledge of the longitude, of the latitude, and of the time at the place of observation is not required; all that is necessary to be known is the time of duration from the internal contact at the ingress, to the internal contact at the egress, and that the clock moved equably during the

interval of the contacts, and that the least distance of the centers of the Sun and Venus, as seen from the center of the earth, is also known.

The method I have followed, in this enquiry, was by finding the total duration at the center of the earth: in order to find this, it was necessary to know the least distance of the centers of the Sun and Venus as seen from the center of the earth. By the measurements of the distance of the limb of Venus from the Sun's limb taken at Savile-House, and also by the like measurements taken by Mr. Haydon at Lefkeard, I found, on the above supposition of the Sun's parallax, that the least distance of the centers, as seen from the center of the earth, was  $= 9' 32''$ . The total duration, therefore, at the center of the earth was  $5^h 58' 1''$ . I have compared the several observations of the total duration with this central duration, and from each I have determined the Sun's parallax, as may be seen more fully in the following table. I have inserted in this table the alteration of duration by one second of the Sun's parallax at each place, by which may be seen the quantity of error in the determination of the Sun's parallax arising from any quantity of error in the observation.

The times of the total duration at those different places I have taken from the Phil. Transactions; only those of Calmar and Cajaneburg I have taken from the Sweedish acts; the internal contact at the ingress at Cajaneburgh, in those acts, is at  $4^h 18' 5''$ , whereas it should be at  $4^h 19' 5''$ , as may be easily proved, this being an error in writing down the minutes, which has happened more than once in these observations, occasioned by the hurry of writing down the times of the observations. The observations in the

East Indies I have taken from letters sent by the East India Company to the Royal Society. I have also been obliged to make a correction of the minutes in the observation at Tranquebar and at the Grand Mount, a place about 8 miles to the S. West of Madras.

I. Cajaneb.	2. Calmar.	3. Calcutta.	4. Hernof.	5. Abo.	6. Tobolik.	7. Stockholm	8. Stockholm	
5 58 8 5	h 58 7 21	h 58 7 30	h 58 7 36	h 58 7 46	h 58 9 3	h 58 7 34	h 58 7 34	Duration at the centre of the earth.
5 49 56 5 49 54	5 50 45 5 50 35	5 50 31 5 50 36	5 50 25 5 50 15 5 50 26 5 50 15	5 48 58 9 5 48 50	5 50 27 5 50 27 5 50 45 5 50 42	5 50 27 5 50 27 5 50 45 5 50 42	5 50 27 5 50 27 5 50 45 5 50 42	Effect of parallaxes, from a parallax of 8'', 5. Duration observed.
— 2	—	+ 5	+ 1	— 6	— 8	+ 18	+ 15	Diff. of observation and a parallax of 8'', 5.
9° 48' 57"	0° 44' 52"	39° 30' 53°	4° 44' 54"	5° 43' 55"	26° 50' 64"	3° 24' 54"	3° 24' 54"	Altitude of the Sun at ingress without refraction.
8'', 53	8'', 52	8'', 45	8'', 48	8'', 61	8'', 63	8'', 16	8'', 22	Alteration of Duration by 1'' of the Sun's parallax. Parallax of the Sun from the observation.

9. Upfal.	10. Upfal.	II. Upfal.	I2. Tornea.	I3. Tornea.	I4. Madras.	I5. G.Mount	I6. Tranqueb	
h 58 7 33	h 58 7 33	h 58 7 33	h 58 8 7	h 58 8 7	h 58 6 33	h 58 6 33	h 58 6 24	Duration at the center of the earth.
5 50 28 5 50 7	5 50 28 5 50 2	5 50 28 5 50 2	5 49 54 5 49 54 5 50 9 5 50 21	5 49 54 5 49 54 5 51 21 5 51 43	5 52 28 5 51 20	5 52 28 5 51 20	5 51 37 5 51 33	Effect of parallaxes, from a parallax of 8'', 5 of the Sun.
— 21	— 26	— 2	+ 15	+ 27	+ 15	— 8	— 4	Duration from a parallax of 8'', 5 of the Sun.
3° 29'	3° 29'	3° 29'	— 9° 33'	9° 33'	29° 27'	29° 25'	28° 44'	Duration observed.
54''	54''	54''	57''	57''	46''	46''	45''	Diff. of observation and a parallax of 8'', 5.
8'', 89	8'', 98	8'', 54	8'', 24	8'', 03	8'', 17	8'', 67	8'', 59	Altitude of the Sun at ingress without refraction.
								Alteration of duration by 1'' of the Sun's parallax.
								Parallax of the Sun from the observation.

This table explains itself. If we, therefore, take the mean of the Sun's parallax arising from each of those sixteen total durations, it will be found = 8'', 48, and if we reject the observations of number 7th, 8th, 9th, 10th, 12th, 13th, and 14th, which differ the most from the rest, the mean of the nine remaining ones gives the Sun's parallax = 8'', 55, agreeing, to a surprizing exactness, with that found

by the observations of the internal contact at the egress.

The observations at Tobolsk and Cajaneburg I look upon as very good ones, they differing in the total duration only six seconds; this error in observation, from what is gone before, may be very easily allowed. The observation of the internal contact at the ingress at Stockholm is, I believe, too soon, and the uncertainty of this observation may be easily granted, when it is considered, that the Sun was only 3 or 4 degrees above the horizon at that time, and we find a difference of 22" between the observers at Upsal, where the sun was about the same altitude. This, I apprehend, was owing to the undulation on the limb of the Sun, occasioned by the vapours near the horizon: but the same reason cannot be given for the observation at Tornea, where the Sun was about 10<sup>d</sup> degrees high, at the time of the internal contact at the ingress, unless there was an undulation at that altitude also, which may have been the case, though not mentioned. I have reason to believe that the error of observation at Tornea is at the egress, where indeed the two observers differ considerably.

The parallax of the Sun being thus found, by the observations of the internal contact at the egress, = 8", 52 on the day of the transit, the mean horizontal parallax of the Sun is = 8", 65.

I cannot help taking notice on this occasion, of a method employed by some astronomers, of determining the diameter of Venus by the duration of the egress over the Sun's limb: for I am fully satisfied, that the best eye, assisted by the best telescope, and in the best and clearest air, could not see the very

very last contact of Venus with the Sun's limb, but must have lost sight of it several seconds before she really had left the Sun's limb; and this will the more plainly appear, when it is considered that every second of the diameter of Venus took up about  $19''$  of time in passing over the Sun's limb. And to shew this further, and in a stronger light, I shall mention the following particulars. Mr. Canton measured the diameter of Venus, and found it  $= 58''$ , but by his duration of the egress, the diameter of Venus is  $= 57''$ , 8: the same diameter was measured by myself at Savile-house, and found  $= 59''$ , but by the duration of the egress observed there, the diameter of Venus is  $= 58''$ , 6. Mr. Mason also at the Cape measured the diameter of Venus, which he found  $= 59'', \frac{1}{4}$ , but by his duration of the egress her diameter is found  $= 57'', 0$ : and therefore I must conclude that the diameter of Venus, found by the duration of the egress, must be always less than the true diameter for the reason given above. And, since I am upon this subject, I shall likewise mention the times of duration of the egress from several diameters of Venus. If the diameter of Venus is supposed  $= 57''$ , then the duration of the egress at London should have been  $= 18', 9''$ ; if the diameter is  $= 58''$ , then the duration at London will be found  $= 18' 28''$ ; and if the diameter is  $= 59''$ , then the duration of the egress at London will be found  $= 18' 47''$ . The diameter of Venus being  $= 59''$ , and the diameter of the Sun  $= 31' 31''$ , the duration of the egress at Stockholm is  $= 18' 43''$ , at Paris  $= 18' 45''$ , at the Cape of Good Hope  $= 18' 8''$ , and at Rome  $18' 38''$ . The duration of the egress at this last place was observed

served =  $18' 31''$ , and if we suppose the diameter of Venus =  $58''$ , and the diameter of the Sun =  $31', 33''$ , the duration of the egress at Rome will be found =  $18' 18''$ , which duration being less than the observed duration, it, therefore, follows that the diameter of Venus was more than  $58''$  on the day of the transit, and the duration of the egress at Paris, observed by M. de la Lande and P. Clouet, by Mr. Mallet and Mr. Bergman at Upsal, by M. Chappe at Tobolsk, and by myself at Savile-House, prove the same thing.

Observations of the transit of Venus and Mercury over the Sun have been reckoned by astronomers (if the Sun's parallax is known) as very proper to determine the differences of the longitudes of the places of observation, even in many respects preferable to the observations of Jupiter's satellites. I shall therefore set down in the following table the longitudes from Greenwich observatory of the different places, where the late transit of Venus was observed, drawn from the said observations.

Places.	Longitude in time	Latitude.
	h   '   "	°   '   "
Greenwich Observatory	00 00 00	51 28 37 North.
Shirburn Castle	0 3 47 West.	51 39 22 N.
Leskeard, Cornwall	0 18 47 W.	50 26 55 N.
Paris	0 9 10 East.	48 50 14 N.
Bologna, Italy	0 45 15 E.	44 29 36 N.
Rome	0 49 38 E.	41 53 54 N.
Drontheim, Norway	0 44 16 E.	63 26 10 N.
Upsal	1 10 16 E.	59 51 50 N.
Stockholm	1 12 17 E.	59 20 30 N.
Hernosand	1 11 7 E.	60 38 0 N.
Calmar	1 5 28 E.	56 40 30 N.
Abo	1 28 18 E.	60 27 0 N.
Tornea	1 36 44 E.	65 50 50 N.
Cajaneburg	1 51 47 E.	64 13 30 N.
Tobolsk, Siberia *	4 32 52 E.	58 12 22 N.
Madrid	0 13 26 W.	40 25 0 N.
St. John's, Newfoundl.	3 31 12 W.	47 32 0 N.
Madras	5 20 10 E.	13 8 0 N.
Rodrigues	4 12 34 E.	19 40 40 South.
Cape of Good Hope	1 13 31 E.	33 55 42 S.
Calcutta, Bengall	5 53 44 E.	22 30 0 N.
St. Petersburgh	2 1 29 E.	59 56 0 N.
Tranquebar	5 18 8 E.	10 56 0 N.
Pondicherry	5 15 50 E.	11 56 30 N.
Kingston, Jamaica †	5 6 52 W.	
Port Royal, Jamaica	5 7 2 W.	

§ If the observation at Savile-House is compared with the observation of M. de la Lande at Paris, the difference of longitude between the royal observatories at Greenwich and Paris is = 9' 16".

\* The latitude of this place was sent to the Royal Society, but no longitude of it, and therefore the internal contact at Tobolsk could not be compared with that

that at the Cape of Good Hope for the purpose of the Sun's parallax.

† Mr. professor Winthrop went, at the expence of the province of Massachuset's-Bay, to St. John's in Newfoundland, to observe the tranfit of Venus, which he did with great care, and as much exactness as the low situation of the sun at that time would permit. The internal contact happened there at  $4^h 47' 17''$ . He had no other way of determining his longitude from Greenwich, at that time of the year, but by taking the distance of a star from the Moon, which gave him  $3^h 20' 56''$  for his longitude from Greenwich, and therefore his observation of the internal contact could not be compared with the same observation at the Cape.

‡ The longitude of Kingston in Jamaica is determined by the observation of the transit of Mercury over the Sun on the 25th of October 1743 O. S. mentioned in the Phil. Transactions: the effect of the parallaxes is considered, and here included.

The longitudes of Tornea and Madrass are determined from the contact at the egress, because I have good reason to believe that the observation at the egress at these two places was not correct, and the observation of the contact at the ingress is more certain than that of the egress, and the observers at the ingress at these two places agree to  $2''$ .

The elements I made use of in the preceding calculations are

The Sun's diameter - - - - - =  $^{\circ} 31' 31''$

The diameter of Venus - - - - - =  $^{\circ} 0' 59''$

The horary motion of Venus in her path - - - - - } =  $^{\circ} 3' 59,8$

The angle of the orbit of Venus with the ecliptic } =  $8^{\circ} 30' 10''$   
 The distance of the centers of the Sun and Venus as seen from the center of the earth } =  $0^{\circ} 9^{\prime} 32''$   
 The difference of the parallaxes of the Sun and Venus } =  $0^{\circ} 0^{\prime} 21, 35''$

I shall now give the method I followed in these calculations.

In Tab. XIX. Fig. 1st. Let FG represent the horizon, ZVH a vertical circle passing thro' the center of Venus, PVR a circle of declination, BV a circle of latitude, EC the ecliptic, OVN the orbit of Venus, VL the parallax of altitude, VN the parallax of longitude, LN the parallax of Latitude, ZVP the angle of the vertical with the circle of declination, BVP the angle of the equator with the ecliptic, ZVB the angle of the vertical with the circle of latitude, EVO the angle of the orbit of Venus with the ecliptic, ZVO the angle of the orbit of Venus with the vertical, ZP the complement of the latitude of the place, VP the complement of the declination of the planet, ZPV the horary angle or distance of the planet from the meridian, ZV the complement of the altitude of the planet.

In the triangle ZPV, the sides ZP and PV and the angle ZPV are given, therefore the angle ZVP may be found, and also the side ZV, and as the parallax of altitude is to the horizontal parallax as the cosine of the apparent altitude is to the radius, therefore LV is found. BVP added to or subtracted from ZVP, as the nature of the case requires, leaves the angle

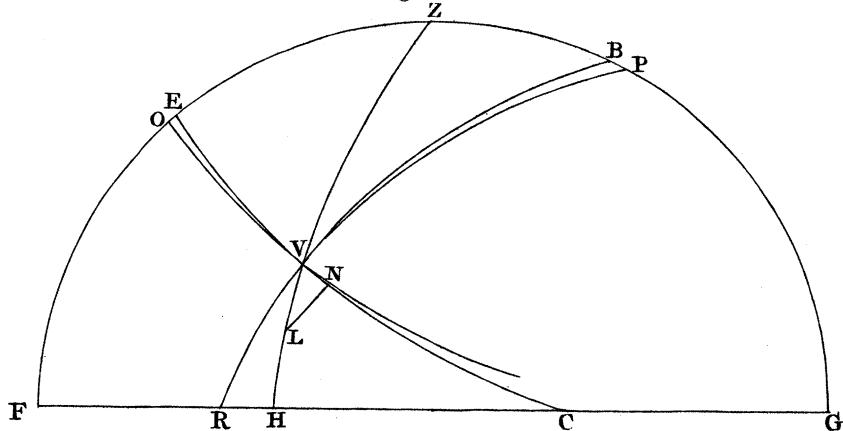
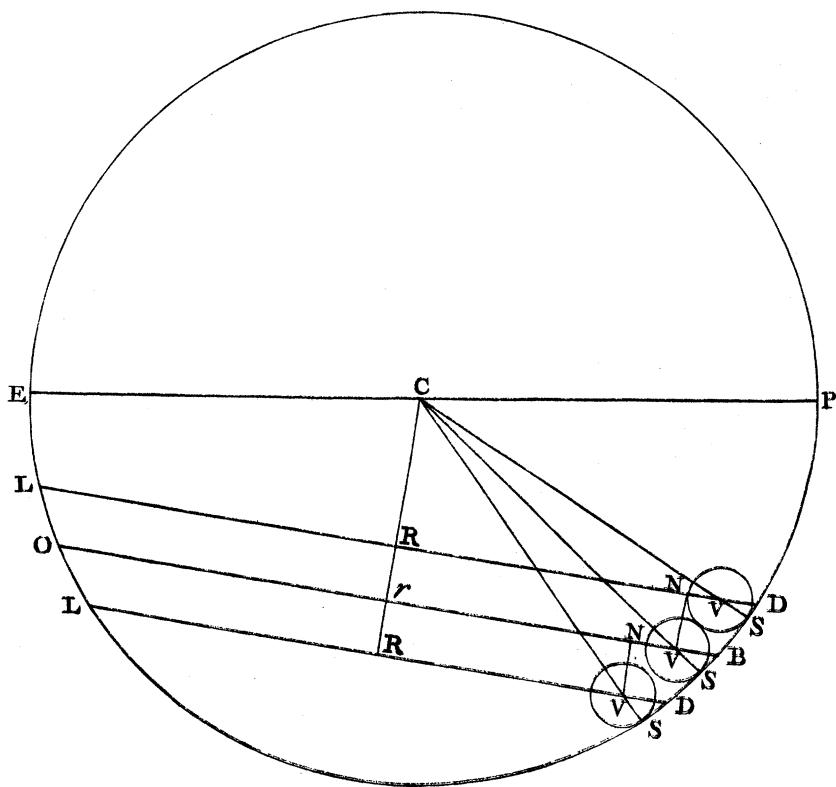


Fig. 2.



angle ZVB; the angle ZVB subtracted from BVO leaves ZVO = to the angle of the orbit of Venus with the vertical, ZVO = L VN. Therefore in the right-angled triangle LNV, the angle L VN being given, and the side LV, the side VN, = the parallax of longitude, and the side LN, = to the parallax of latitude, may be found. The parallax of longitude is reduced to time by knowing the horary motion of Venus in her orbit or path. Thus the value of one second of longitude is known in time. But to reduce the parallax of latitude to time, in Fig. 2d. Let ECP represent the ecliptic, Or B the path of Venus over the Sun as seen from the center of the earth, LRD the path of Venus as affected by parallax at any one place, Cr the nearest distance of the centers of the Sun and Venus as seen from the center of the earth, CR the nearest distance of the same centers as seen from the place of observation, Rr or NV the parallax of latitude, CS the Sun's semidiameter, VS the semidiameter of Venus, Nv the difference of the semichords rv and RV, CV and Cv = the difference of the semidiameters of the Sun and Venus.

In the right-angled triangles Crv and CRV, two sides are given, therefore the other sides rv and RV may be found the difference of these two sides Nv being reduced to time, by the horary motion of Venus in her path, will give the time answering to the parallax of latitude. The parallax of longitude being added to or subtracted from the Parallax of latitude, as the case requires, will give the retardation or acceleration of the contact at the place of observation, after

after or before the contact as seen from the center of the earth.

In all the above calculations, I have considered the place of Venus, with respect to the center of the Sun, both in right ascension and declination; and I have neglected the fractions of seconds in the results of the parallaxes of longitude and latitude, and I have always taken the second that was nearest to the fractional part.

I take this opportunity of acquainting the Royal Society, that I have, by means of an achromatic object-glass micrometer of 40 feet focus adapted to a reflecting telescope of two feet focal Length, measured the least and greatest diameters of the Sun, and I find the apogeal diameter = 31' 28", and the perigeal diameter = 32' 33'.